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SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO.

BY

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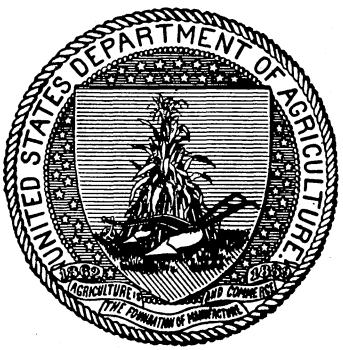

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 18, 1911.

SIR: We have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "Spraying Peaches for the Control of Brown-Rot, Scab, and Curculio," by W. M. Scott, of the Bureau of Plant Industry, and A. L. Quaintance, of the Bureau of Entomology.

The loss to the peach growers of the United States from brown-rot, scab, and curculio amounts to millions of dollars annually, and until recently there has been no effective means of preventing this great shrinkage. Experiments conducted by this department during the past four years, however, have abundantly demonstrated that these troubles can be thoroughly controlled at a small cost. The results of experiments and demonstrations conducted during 1910 and instructions for the application of the treatment are contained in the accompanying manuscript.

Respectfully,

WM. A. TAYLOR,
Acting Chief, Bureau of Plant Industry.
L. O. HOWARD,
Chief, Bureau of Entomology.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO.

INTRODUCTION.

The peach-growing industry in the United States at the present time has become a very important one, being second in extent among fruits only to the cultivation of the apple. According to the 1900 census there were in the territory east of the Rocky Mountains, which is subject to the troubles treated in this bulletin, approximately 91,000,000 bearing peach trees. Since that time the number of bearing trees has increased by perhaps one-fourth, making a possible total of 113,750,000 trees. Careful estimates indicate that the quantity of fruit annually harvested by peach growers in this territory is not less than 10,000,000 bushels. Thus the crop for 1910, although an unusually large one, was for the territory mentioned, probably not less than 12,000 000 bushels, with a gross valuation of about $12,000,000 to $16,000,000.

Although many insects and parasitic fungi occur on the peach, comparatively few are of much economic importance. Of the diseases of the peach, the brown-rot (*Sclerotinia fructigena* (Pers.) Schröt.) and scab, or black-spot (*Cladosporium carpophilum* Thüm.), are responsible for practically all of the damage to the fruit crop and the insect injury is limited almost entirely to the attack of one species, the plum curculio (*Conotrachelus nenuphar* Herbst.).

The brown-rot probably causes more loss to peach growers than all other maladies of the peach combined, with perhaps the exception of "yellows," which kills the trees outright. In the South the brown-rot often causes the destruction of half or even practically all of the crop, and throughout the territory under consideration the annual shrinkage in yield is perhaps 25 to 35 per cent of the crop, representing a valuation of about $3,000,000 to $4,000,000. Although the brown-rot is always present in the peach orchards of humid sections, causing a rotting of a certain proportion of the fruit, it becomes notably destructive only under certain weather conditions, when within a period of 10 days or two weeks it will spread so rapidly as to result in the destruction of practically the entire crop. Such disastrous

outbreaks are likely to occur during moist, humid weather as the fruit begins to ripen. The brilliant prospects of the orchardists are thus within a few days obliterated as if by fire.

The peach scab is the only other destructive disease of the fruit in the eastern United States, and, while it does not occur in such sudden and disastrous outbreaks, the sum total of the injuries caused by it are very important, resulting in a shrinkage in crop values of perhaps $1,000,000 annually. This disease occurs all over humid America where the peach is grown and is especially troublesome east of the Allegheny Mountains. It not only renders much of the fruit unfit for market, but so mars the appearance of the marketed fruit as to reduce its value.

The plum curculio is of scarcely less importance in its relation to the successful production of the peach than the diseases above mentioned. By its punctures of the fruit in feeding and egg laying and the injury resulting from the larvæ, or grubs, within the fruit it brings about a reduction in yield of a valuation amounting to perhaps not less than $3,750,000 annually. The puncturing of the fruit also greatly favors the brown-rot, and curculio control is a prime essential in preventing losses from this malady. Although the plum curculio is very generally distributed eastward of the Rocky Mountains, it is especially abundant in the Middle and Southern States. During years of full fruit crops its injuries are less important, simply more or less thinning the fruit; but when the crop is light little fruit may escape its ravages.

The troubles mentioned have more than kept pace with the development of the peach-growing industry, and the cultivation of this crop, especially in the South, has become more and more hazardous. Practical means for their control have, therefore, been most urgently needed, and much attention has been given by investigators of the Department of Agriculture and of the various agricultural experiment stations to supply this want. While it has been possible by the use of certain sprays, such as Bordeaux mixture and Paris green, to effectively reduce these troubles, the sensitiveness of the foliage and fruit of the peach has practically prevented their employment, and the peach grower has been almost helpless against them. A spray effective in the control of these troubles and which at the same time may be used with perfect safety on the trees and fruit has been the most important requirement to place the industry on a reasonably secure foundation.

Experiments begun by the Bureau of Plant Industry some three or four years ago and carried out under varying climatic and other conditions in different parts of the eastern United States have established beyond question the effectiveness of the self-boiled lime-

sulphur wash for the control of the fungous troubles mentioned. Earlier experiments by the Bureau of Entomology had already shown that by the proper use of arsenate of lead the curculio could be largely controlled, though on account of danger of foliage injury its use had not been unqualifiedly recommended. Cooperative experiments between the two bureaus have shown that the fungicide and arsenical may be used as a combined spray with satisfactory results in controlling these troubles and without injury to the fruit and foliage of the peach. Hence, there is now available a satisfactory method for the control of these three serious obstacles to successful peach culture.

In the following pages the brown-rot, peach scab, and curculio are treated with reference to their occurrence on the peach, and results are given of experiments and demonstrations in their control conducted jointly by the Bureau of Plant Industry and the Bureau of Entomology during 1910. The writers were assisted in this work by E. L. Jenne and E. W. Scott, of the Bureau of Entomology, and by Leslie Pierce and G. W. Keitt, of the Bureau of Plant Industry.

BROWN-ROT.

NATURE AND CAUSE OF THE DISEASE.

Brown-rot is a fungous disease which affects the stone fruits, such as the peach, plum, and cherry, and to a less extent some of the pome fruits, such as the apple, pear, and quince, producing a so-called rot of the fruit and blight of the twigs. It is caused by a fungus known to botanists as *Sclerotinia fructigena* (Pers.) Schröt. Brown-rot is the common name usually applied to the disease, but monilia, the generic name of the imperfect stage of the fungus, is often used by some of the older fruit growers.

The disease appears on the fruit as a small circular brown spot, which under moist, warm conditions enlarges rapidly, soon involving the entire fruit in decay (fig. 1). The spots do not usually become sunken, and the fruit remains plump until almost entirely decayed. The fungus growing in the tissues of the fruit breaks through the skin, forming small, grayish tufts of spore-bearing threads. These tufts, although few on young spots, soon become so numerous as to give the diseased area a grayish, moldy appearance, which is responsible for the term "peach mold" sometimes applied to the disease. The spores which are produced in great abundance by these fungous tufts are blown by the wind and carried by insects and birds from fruit to fruit, tree to tree, and orchard to orchard. Finding lodgment on the fruit under favorable conditions of temperature and moisture, these spores germinate, producing a fungous

growth, which ramifies and kills the tissues. These dead tissues turn brown, and the fungus breaks through the surface, producing another crop of spores. The process is very rapid, only a few days intervening between one generation of spores and another.

DAMAGE TO THE PEACH.

Although the young fruits soon after the petals are shed may become affected, as a rule no marked outbreak occurs until the fruit is half grown or larger, and the greatest destruction is wrought at harvest time. The fruit crop may reach maturity in perfect condition and yet be destroyed before it can be picked. Moreover, the fruit may become affected in transit or after reaching the market. It is no uncommon experience among peach growers to have a carload of peaches leave the orchard in apparently good condition and

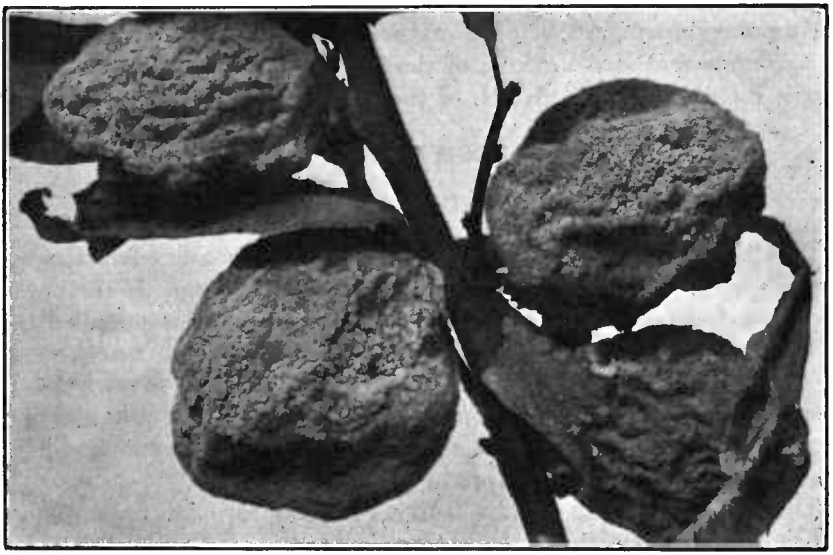

FIG. 1.—Peaches entirely destroyed by brown-rot, showing gray masses of spores of the fungus.

arrive on the market specked and practically worthless, owing to the brown-rot fungus. Through handling by pickers and packers some fruit in every package may become contaminated with spores from a few diseased fruits in the orchard. Enough moisture usually develops in the car to germinate the spores, and if the refrigeration is poor the fruit is likely to go down in partial or total decay before reaching the consumer.

The fungus also attacks the blossoms and extends from these into the fruit-bearing twigs, often girdling them. In a wet spring the fruit crop may thus be materially reduced, although this form of attack is only occasionally serious. In like manner the fungus may

extend from diseased fruits into the twigs. Following an outbreak of brown-rot on the fruit, these twig infections may become so severe as to give the trees a blighted appearance.

WINTER STAGE AND SOURCE OF INFECTION.

The affected fruits largely drop to the ground, although many of them hang on the trees for months. They become dried and shriveled, and at this stage are known as brown-rot mummies. The fungus passes the winter in these mummies, which form the chief source of infection for the new fruit crop. When moistened by spring rains, the mummified fruits on the trees and on the ground become covered with fruiting tufts of the fungus, producing countless numbers of spores.

After 18 months, or at the end of the second winter, about the time peach trees are in bloom, there arise from the mummies on the ground, partly or entirely covered with soil, fruiting bodies representing the perfect stage of the fungus. These are dark-brown somewhat bell-shaped disks, resembling toadstools. In them are produced an abundance of ascospores, which rise in the air and are wafted by the wind. These, as well as the summer spores (conidia), serve to infect the blossoms and young fruits. The propagation of the fungus being thus so abundantly provided for, it is not surprising that a crop of fruit may be destroyed without much warning.

INFLUENCE OF THE WEATHER AND INSECTS.

In sections where the brown-rot is prevalent the spores are practically omnipresent, and only favorable conditions for their germination and the rapid growth of the fungus are required to start an outbreak of the disease. The most important factor is excessive moisture in the form of rain, which not only favors the production and germination of the spores and the growth of the fungus, but renders the fruit soft and watery, and therefore more susceptible to the disease. High temperatures also favor the disease, although the fungus grows readily in mild summer temperatures. Prolonged cloudy weather with frequent light showers is more dangerous than a hard rain followed by clearing. Warm, muggy weather, when the fruit is maturing, is often disastrous to the crop.

Insects, especially the curculio and certain plant bugs, play an important part in the distribution of the spores and the infection of the fruit. Although the fungus under favorable conditions is apparently able to pass readily through the unbroken skin of the fruit, it is greatly aided by insect abrasions. In the process of feeding and egg laying, the curculio punctures the skin of the fruit, opening the way for the fungus and in many cases perhaps actually inserting the spores. This insect may render spraying for brown-rot partially

ineffective by breaking the sprayed skin of the fruit, thus exposing the flesh to attack. In the treatment of the disease it is, therefore, important to combine an insecticide with the fungicide so as to destroy the beetles.

TREATMENT.

Experiments conducted by the Bureau of Plant Industry during the past four years have shown conclusively that this disease can be controlled by the use of self-boiled lime-sulphur mixture.[1]

A schedule of applications for the combined treatment of brown-rot, scab, and curculio is given on pages 38–40 of this bulletin.

PEACH SCAB.

ECONOMIC IMPORTANCE OF THE DISEASE.

Of the diseases affecting the fruit of the peach, scab is second only to brown-rot in economic importance; in fact, it is more destructive

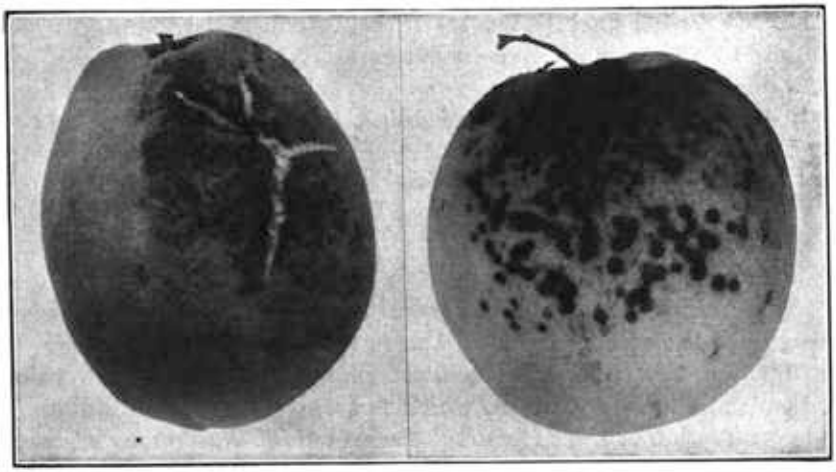

FIG. 2.—Peach scab on Elberta peaches, showing spots and cracks caused by the disease.

than brown-rot in some of the mountain districts. It dwarfs the fruit and causes premature dropping, thereby reducing the yield; it ruptures the skin, opening the way for brown-rot attacks; and it mars the appearance of the fruit, thus lowering the grade and reducing its market value. The disease is common wherever peaches are grown east of the Rocky Mountains, scarcely an orchard being entirely free from it. In some cases, especially in a dry season, only a small percentage of the fruit may become affected and with only a few small harmless spots, while in other cases the entire crop may become so badly affected as to be unmarketable. If the loss in the orchard

[1] Circulars 1 and 27 and Bulletin 174, Bureau of Plant Industry, U. S. Dept. of Agriculture.

and the reduction in market value are both considered, it seems evident that a loss of 10 per cent of the total value of the peach crop in the eastern United States is caused by peach scab.

THE NATURE AND CAUSE OF THE DISEASE.

The name commonly applied to this disease is "peach scab," but it is also known as "black spot" and "freckles" and in some districts it is often improperly called "mildew." It is caused by the fungus *Cladosporium carpophilum* Thüm., which grows in the skin of the fruit, producing small, circular dark-brown spots. When numerous, these spots give the fruit a smutty or blackened appearance and cause the skin to crack (fig. 2). Fruit badly affected does not reach normal size and often drops prematurely.

The fungus also attacks the twigs, producing brown spots, in which it passes the winter. These spots are very common in peach orchards,

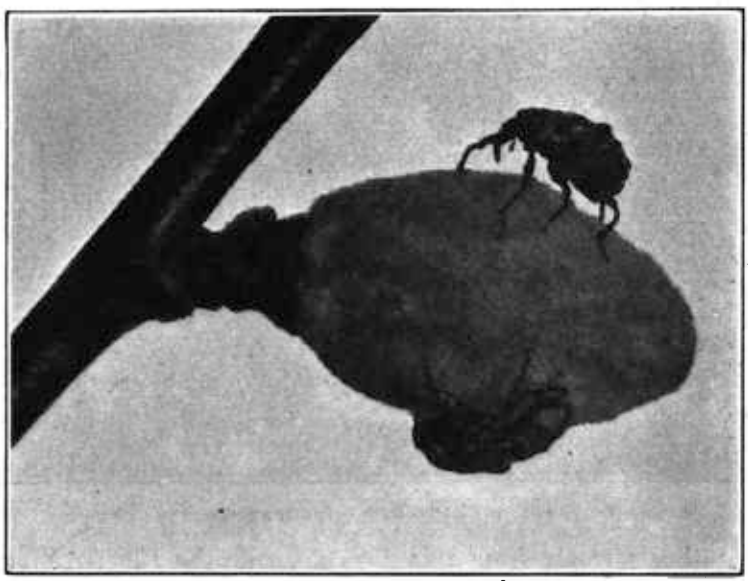

FIG. 3.—Two adult curculios on a young peach. (Considerably enlarged.)

but they apparently do little damage to the twigs. During the spring or early summer the fungus growing in the spots produces olive-brown spores which serve to infect the young peaches. Similar spores are also produced on the fruit spots.

THE SUSCEPTIBILITY OF VARIETIES.

There is a considerable difference in varieties as to their susceptibility to peach scab. In general, the late varieties are much more susceptible than the early varieties. This is due, in part at least,

to the fact that the fruit of the late-maturing varieties is exposed to infection over a longer period and the opportunity for the development of the disease is greater. Of the commercial varieties, the Heath is perhaps the most susceptible; in fact, the disease has almost prohibited the growing of this variety except in a small way. The Bilyeu variety is also badly affected and the disease has restricted its culture to high, well-drained locations. The Salway, Smock, and most of the other varieties that ripen after the Elberta usually

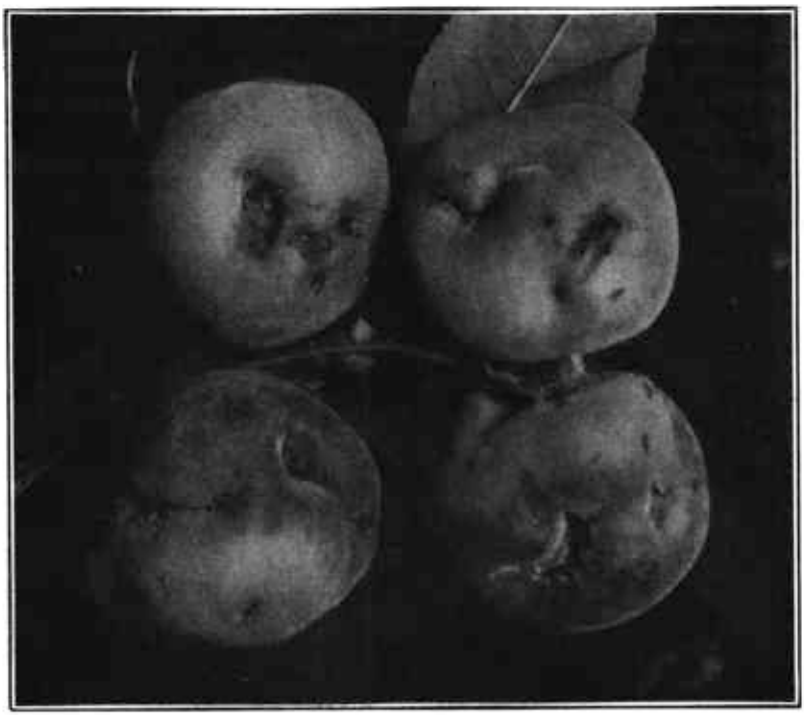

FIG. 4.—Deformed ripe peaches resulting from feeding and egg-laying punctures.

suffer rather severely from this disease, while the Elberta may be considered somewhat less affected, although the crop of this variety often becomes badly diseased. The varieties that ripen earlier than Elberta are as a rule only slightly or moderately affected. This is especially true of the Carman, Hiley, Champion, and Belle. On the other hand, the Mountain Rose and Early Rivers are quite susceptible to the disease.

TREATMENT.

The development of the self-boiled lime-sulphur mixture as a fungicide has made possible the control of the scab without injury to the fruit or foliage. The injury produced by this disease may be almost

entirely prevented at a small cost. This has been abundantly demonstrated through experiments conducted by the Bureau of Plant Industry during the past three or four years.[1] The schedule of applications for the control of this disease, together with the brown-rot and curculio, is given on pages 38–40 of this bulletin.

THE PLUM CURCULIO.

WHAT THE CURCULIO IS.

The curculio is a small snout beetle of the family Curculionidæ, which contains many species of economic importance. The adult

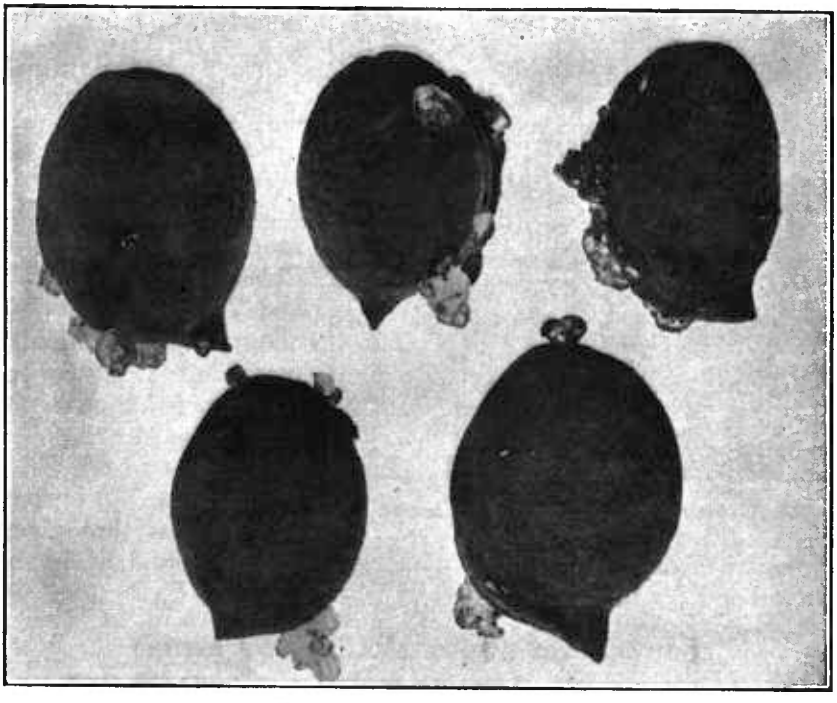

FIG. 5.—Peaches showing the exudation of gum from curculio punctures.

insects vary somewhat in size, but will average about three-sixteenths of an inch in length. Figure 3 illustrates two beetles on a newly set peach, all considerably enlarged. In the course of its growth the insect passes through four stages, namely, the egg, larva, pupa, and adult. The larva, or grub, is the small whitish worm frequently found in ripe peaches, plums, and cherries and is well known to lovers of these fruits.

There are many common names for this insect, such as the "plum curculio," "plum weevil," "peach curculio," "peach worm," "fruit

[1] Circulars 1 and 27 and Bulletin 174, Bureau of Plant Industry, U. S. Dept. of Agriculture.

weevil," "little Turk," "curculio," etc. The name here used, however, is perhaps best fixed in literature on economic entomology and has been adopted for this species by the American Association of Economic Entomologists.

The plum curculio is a native American insect and fed originally, as it feeds at the present time, on wild plums and other wild fruits, especially Crataegus. Its injuries were noted as long ago as 1736, and it was the subject of an extended article published in 1804. Our early horticultural literature abounds with references to its depredations, especially to plums, which were apparently grown with the greatest difficulty.

FIG. 6.—Peach infested with curculio larva, or grub.

So far as is known, the plum curculio is still confined to North America, ranging from southern Canada south to Florida and Texas and west to about the one hundredth meridian. It appears to be restricted in its westward spread by the more arid climate of the Great Plains region. It is probably present throughout its entire area of distribution, but is especially abundant in the Central and Southern States.

FOOD PLANTS AND CHARACTER OF INJURY.

Practically all stone and pome fruits, such as peaches, plums, apricots, nectarines, cherries, apples, pears, etc., are used by the curculio for feeding and egg-laying purposes. Injury is done by both the adult and larva. The former punctures the fruit in feeding and in egg laying, and the grubs live within the fruit and spoil it for market or other purposes. The character and extent of injury vary with different fruits, and while the present paper deals with the insect as an enemy of the peach the statements here made are fairly applicable to other stone fruits, such as plums, cherries, apricots, and nectarines.

Most of the peaches punctured while small soon fall from the effect of the injury or on account of the presence of the developing grubs. After a peach is of some size, about one third grown, most of the larvæ apparently are unable to develop successfully in it, owing to its vigorous growth. There is a considerable period, therefore, when the curculio is able to inflict but little damage to vigorous-growing peaches, though the fruit may be more or less scarred by the feeding and egg punctures, from which gum may exude, especially during moist weather (figs. 4 and 5). As stated elsewhere, these punctures and the exudation of gum greatly favor the brown-rot, forming a nidus for spores of the fungus and furnishing an easy point of infection. After the period of rapid growth of peaches has passed and the ripening process has begun, the curculio larva is able to develop readily in the fruit and, as the beetles are still ovipositing when early and midsummer varieties are ripening, wormy ripe peaches are often to be noted at picking time. The loss caused by worminess of fruit (fig. 6), while often quite important, is perhaps less so than that resulting from the "stings" which deform and scar the fruit. Wormy fruit and that which is scarred to any extent ripen prematurely, as a rule, and in untreated orchards may constitute a considerable proportion of the crop.

LIFE HISTORY AND HABITS.

How the curculio passes the winter.—The curculio passes the winter in the adult or beetle stage under trash in orchards, along fences, terraces, etc., but especially in woods adjacent to orchards. The beetles come out of hibernation in the spring at about the blooming period of the peach, feeding at first upon the buds and foliage and later also upon the fruit.

Occurrence in orchards.—The invasion by the beetles of orchards in spring and the effect on their abundance of neighboring woods have been several times investigated. Much may be done to reduce their number by keeping the orchards and surroundings free from trash. Where practicable, it will be desirable to burn over in early spring woods adjacent to orchards in order to destroy the beetles hibernating there. Jarring records of considerable areas of peach orchards have been made which show the occurrence of the curculio first in large numbers adjacent to woods, terraces, or other favoring places. Table I shows the results of a jarring record made by Messrs. E. W. Scott and E. L. Jenne, at Barnesville, Ga., during 1910. Figure 7 illustrates the arrangement of the trees with respect to their surroundings.

Considering the results of the jarring records for the individual rows, the influence of the woods is very evident. A total of 476 beetles was taken from rows 1 and 2, adjacent to woods, up to March 23, as compared with a total of 61 beetles from the remaining eight rows. Fifteen days after the emergence from hibernation of the beetles began, namely, by March 25, their diffusion had become quite general all over the orchard, though the first one or two rows always showed on a given date a greater number of individuals than any other row. During the season a total of 3,197 beetles was taken from row 1, or 42.64 per cent of all captured. The first three rows adjacent to the woods gave for the season 4,813 beetles, or 64.19 per cent of the total for the entire plat. Between rows 9 and 10, as shown in the diagram, there was a terrace covered with grass and trash, and its influence on the abundance of the insects is also to be

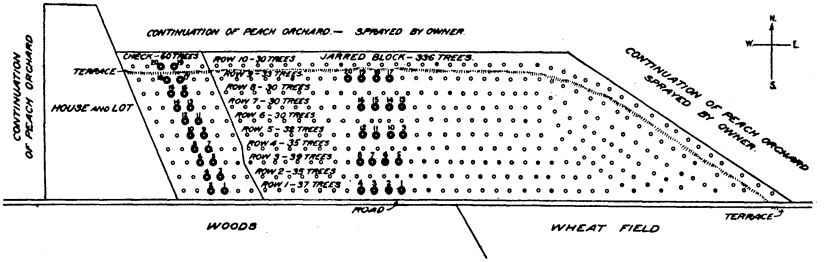

FIG. 7.—Plan of a block of peach trees jarred for the curculio, showing the arrangement of the trees.

noted, more individuals being taken on these respective rows than from any one of the rows 4 to 8, inclusive.

The Georgia record also shows that beetles were out in maximum numbers from March 25 to April 3, or about 10 days to 2 weeks after the trees were in bloom. During this period, 4,108 individuals were captured, or 54.79 per cent of the catch for the season. However, during all of May and June the beetles were fairly abundant, but they diminished perceptibly during July and August. The increase in numbers, evident with the third week in August, is perhaps due to the appearance of beetles developing from ripe peaches or those of a second generation, for the development of which some evidence was obtained under laboratory conditions. Apparently all of the beetles had left the trees for hibernation by October 11, as after this date no more individuals were captured.

TABLE I.—*Jarring record for the plum curculio on the peach, Barnesville, Ga., 1910.*

Dates of jarring.	Number of curculio caught, by rows and dates.										Total.
	Row 1.	Row 2.	Row 3.	Row 4.	Row 5.	Row 6.	Row 7.	Row 8.	Row 9.	Row 10.	
Mar. 10....	16	0	2	0	0	0	0	1	0	0	19
14....	5	1	0	0	1	0	0	0	1	1	9
16....	0	1	0	0	0	0	0	0	0	0	1
18....	3	1	0	0	0	0	0	0	0	1	5
21....	15	1	1	1	0	1	0	0	0	1	20
23....	406	27	10	6	0	6	7	1	5	15	483
25....	460	140	56	45	32	13	14	15	16	49	840
28....	550	125	95	58	38	33	30	33	35	74	1,071
30....	206	77	57	36	21	24	29	21	38	54	563
Apr. 1....	186	74	54	33	18	19	23	18	54	55	534
4....	92	38	45	39	32	29	37	21	45	49	427
6....	93	36	38	17	10	3	2	6	10	28	243
8....	71	23	21	5	3	4	3	6	9	21	166
11....	54	30	16	6	9	10	13	7	7	17	169
13....	34	13	14	4	3	2	5	3	6	11	95
15....	31	8	8	3	0	3	3	1	3	9	69
18....	22	10	8	4	3	3	5	2	5	10	72
20....	5	2	0	1	0	0	0	0	0	4	12
22....	9	11	5	5	2	2	1	3	7	8	53
25....	5	0	1	3	1	0	0	1	2	2	15
27....	3	4	1	1	0	3	2	0	1	1	16
29....	23	8	9	4	2	2	2	4	10	26	90
May 2....	41	21	13	3	7	3	7	6	10	14	125
4....	33	5	5	4	4	2	6	2	6	15	82
6....	12	3	5	1	3	3	0	2	10	13	52
9....	7	5	1	2	0	1	0	0	8	5	29
11....	39	14	3	6	4	2	8	8	9	8	101
13....	13	3	1	0	1	1	1	0	5	6	31
16....	4	1	3	0	1	0	1	0	0	0	10
18....	6	1	0	2	0	0	2	1	2	4	18
20....	37	11	9	5	2	4	6	4	9	11	98
23....	23	6	6	3	3	1	2	1	4	12	61
25....	18	2	3	4	3	0	1	2	4	4	41
27....	15	10	3	3	2	3	1	2	4	6	49
30....	17	10	2	4	3	2	3	2	8	7	58
June 1....	4	1	0	2	2	1	0	0	2	3	15
4....	10	1	1	1	0	2	3	0	6	5	29
7....	81	46	14	7	8	7	8	8	16	36	231
9....	55	14	17	10	6	3	12	11	30	31	189
11....	21	11	6	7	2	4	2	3	3	4	63
14....	44	17	8	2	5	6	5	8	15	17	127
16....	36	25	13	7	4	4	3	4	16	19	131
18....	35	21	9	8	4	7	6	5	21	6	122
20....	15	6	7	2	2	1	4	1	8	8	54
22....	8	2	3	1	2	2	0	0	8	8	34
24....	16	7	2	4	2	3	2	2	8	3	49
27....	16	5	5	4	2	3	3	3	2	8	51
29....	6	7	3	1	3	0	0	1	0	8	29
July 2....	4	3	2	1	1	0	2	1	2	1	17
5....	13	3	2	2	0	1	0	1	0	2	24
8....	6	4	0	0	0	1	0	1	0	4	16
11....	4	3	1	4	2	0	3	1	0	5	23
25....	13	5	3	3	2	0	0	1	3	4	34
29....	12	6	5	3	0	0	0	0	2	1	29
Aug. 2....	10	2	1	1	1	0	0	1	5	3	24
5....	1	3	2	0	0	0	0	0	0	2	8
8....	5	2	2	0	0	0	0	0	0	1	10
Sept. 2....	65	10	4	8	1	1	3	0	2	25	119
5....	36	13	8	3	1	2	2	0	5	8	78
10....	7	1	3	0	1	0	2	0	0	4	18
12....	32	3	4	0	4	1	1	1	2	9	57
16....	14	4	2	0	1	0	0	1	0	2	24
23....	16	5	4	1	2	0	0	0	1	3	32
27....	3	3	1	0	0	0	0	0	0	2	9
30....	8	0	1	1	0	0	0	0	0	1	11
Oct. 4....	1	2	0	0	0	0	0	0	1	0	4
7....	3	1	0	0	0	0	0	0	0	1	5
11....	13	2	1	0	2	0	0	0	1	2	21
15....	0	0	0	0	0	0	0	0	0	0	0
18....	0	0	0	0	0	0	0	0	0	0	0
22....	0	0	0	0	0	0	0	0	0	0	0
Total.	3,197	975	641	393	269	229	275	227	503	788	7,497

Egg-laying habits.—Peaches are less suitable for the egg-laying purposes of the curculio than smooth-skinned fruits, such as plums, apples, etc. Observations by Mr. Jenne indicate that the fuzz may be so copious on young peaches as to prevent the puncturing of the skin by the beetle. He observed that eggs were frequently deposited at the bottom of a tubular boring excavated down in the fuzz as far as the skin of the peach, which was usually scraped somewhat, later resulting in a russet spot on the fruit. In older fruit, however, the female is able to place her eggs under the skin in about the usual manner. In ovipositing, a hole is first excavated through the skin and into the flesh, about as deep as her snout will reach. Turning around, an egg is inserted by means of the ovipositor. Once more turning around, the snout is used to push the egg into the egg cavity and to fill it with bits of surrounding tissue. The next step is to cut the characteristic crescent slit at one side of the egg cavity, the excavation extending back under the egg to prevent its being crushed by the rapid growth of the fruit. Egg and feeding punctures on a newly set plum are shown in figure 8, much enlarged.

FIG. 8.—Egg and feeding punctures of the curculio on a young plum.

Period of oviposition and number of eggs laid.—Egg laying begins as soon as the young fruit is of sufficient size and may continue for several months, depending upon the vitality of the individual beetles. Most of the eggs, however, are laid during the first six or eight weeks after egg laying begins. Many records of the number of eggs deposited by the curculio in plums, peaches, apples, etc., have been made in different localities. Some of these data are shown in Table II. A total of 12,602 eggs is shown from the seven localities.

TABLE II.—*Combined weekly egg-laying records of the plum curculio for various localities and the percentage of eggs deposited within two, four, six, and eight weeks from confinement.*

Locality.	Number of beetles ovipositing.	Total number of eggs laid each week by all beetles of the respective localities.								
		First week.	Second week.	Third week.	Fourth week.	Fifth week.	Sixth week.	Seventh week.	Eighth week.	For remainder of period.
College Park, Md....	9	496	760	414	289	192	98	46	23	153
Youngstown, N. Y..	8	192	186	201	234	204	140	68	57	32
North East, Pa.....	10	81	183	197	94	54	48	18	66	46
Washington, D. C...	4	232	213	242	153	128	108	81	21	46
Myrtle, Ga.....	9	58	62	41	176	50	83	48	40	130
Siloam Springs, Ark.	29	254	300	343	673	619	545	536	350	1,104
Douglas, Mich.....	18	72	259	329	423	229	89	13	..	.....
Total.....	87	1,385	1,963	1,767	2,042	1,476	1,111	810	537	1,511

TABLE II.—*Combined weekly egg-laying records of the plum curculio for various localities and the percentage of eggs deposited within two, four, six, and eight weeks from confinement*—Continued.

Locality.	Total number of eggs.	Number of eggs per individual.			Percentage of total eggs deposited by end of—			
		Maximum.	Minimum.	Average.	Second week.	Fourth week.	Sixth week.	Eighth week.
College Park, Md....	2,471	436	62	274.56	50.83	79.28	91.02	93.81
Youngstown, N. Y..	1,294	257	72	161.75	29.21	62.83	89.40	97.53
North East, Pa.....	787	122	48	78.70	33.55	70.65	83.48	94.17
Washington, D. C...	1,224	557	126	306.00	36.36	68.63	87.91	96.24
Myrtle, Ga.....	688	154	1	76.44	17.44	48.98	68.31	81.10
Siloam Springs, Ark.	4,724	388	4	162.97	11.73	33.23	57.88	76.63
Douglas, Mich.....	1,414	201	25	78.56	23.41	76.59	99.08	100.00
Total.....	12,602	.....	.....	.....	.....	.....	.....	.....
Average for all localities....	.....	.....	.....	144.85	26.57	56.79	77.32	88.01

At College Park, Md., the greatest number deposited by any one female was 426 and the minimum 62, with an average of 274.56 eggs for the individuals under observation. At Youngstown, N. Y., the maximum is 257 and the minimum 72, with an average of 161.75 eggs. At Washington, D. C., under laboratory conditions, a single individual deposited 557 eggs, which is the highest of all records thus far obtained for this insect; the lowest number deposited was 126 and the average for the 4 beetles under observation was 306. At Myrtle, Ga., this range was from 154 as a maximum to a minimum of 1, with an average of 76.44 per individual. At Siloam Springs, Ark., the records include an unusually large number of eggs, namely, 4,724, from 29 beetles. These records show a maximum of 388 and a minimum of 4 eggs, with an average for all pairs of 162.97 eggs. At Douglas, Mich., the records show a range from 201 to 25, with an average for the 18 individuals of 78.56 eggs. The final average number of eggs per female for all localities above mentioned is 144.85, with a range of from 1 to 557.

As shown under the heading "Percentage of total eggs deposited by end of second, fourth, sixth, and eighth week," the proportion deposited by a given time varies for the different localities. There is, however, a general agreement in that the great majority of the eggs have been placed by the end of eight weeks. Approximately, one-fourth of the total eggs are deposited during the first two weeks; one-half have been deposited by the close of the first month; three-fourths within six weeks; and about 88 per cent of the total within eight weeks after the oviposition begins.

Time spent in the fruit.—Records of the time spent in the fruit as the egg and larva have been determined for many individuals and in various localities, including Illinois, District of Columbia, western New York, Georgia, Arkansas, and Michigan.

In all localities the majority of the larvæ emerged within three weeks after the eggs were laid, and, with one exception, emergence had practically ceased by the close of the fourth week.

Time spent in the soil.—When full grown the larva deserts the fruit and burrows below the surface of the soil. Practically none of the larvæ go deeper than 3 inches and the great majority penetrate not more than 2 inches. A small cell is made where the pupal stage is passed and where transformation to the adult or beetle occurs. Some days are spent in the soil by the larva before changing to the pupa, and the newly formed adult may not emerge for several days or even weeks, especially if the ground be dry. The effect of a shower, however, is to bring the new-generation beetles out in numbers.

A large number of observations have also been made on the length of time spent in the soil by different individuals, including a total of several thousand and from about the same localities as already mentioned. All of these observations go to show that comparatively few insects complete their underground transformations in less than three weeks from the time of entering the soil as larvæ. In from four to five weeks, however, the great majority of the beetles are out and by the close of the sixth week emergence has practically ceased.

Time required for transformation from egg to adult.—The average time spent in the fruit for the numerous localities investigated proved to be 19.48 days, and the average time spent in the ground was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Complete life-cycle observations were also made on a total of 597 individuals from many parts of the country, which gave a final average for the period per individual of 50.71 days, differing only a fraction of a day from the time determined in an essentially different manner. Approximately 50 days would therefore appear to be the average life-cycle period for the plum curculio for the country as a whole. The range though, will vary considerably and as actually determined in the case of the individual records was from 37 to 58.45 days.

Habits of beetles from emergence until hibernation.—After emergence, beetles of the new generation feed upon various fruits and plants until fall, when they enter hibernation quarters, appearing the following spring, as already stated. While there is some evidence to indicate that there may be a small second generation in the South, this will be comparatively insignificant and for practical purposes the insect produces but one generation annually. The beetles which develop one summer live over the following winter, ovipositing during the spring and summer, and gradually die off, until by early fall practically all of them have disappeared. The life of the more hardy beetles is thus seen to be some 12 or 14 months

RESULTS OF SPRAYING EXPERIMENTS AND DEMONSTRATIONS DURING 1910.

During the season of 1910 the same experiments were carried out as during 1909, which were reported in Circular 120 of the Bureau of Entomology and in Bulletin 174 of the Bureau of Plant Industry, and in addition the recommendations given in these publications were put in effect on a commercial scale to serve as an object lesson for growers. During 1909 the experiments made in the Hale orchard at Fort Valley, Ga., included the treatment of 1,100 Elberta trees for the control of peach scab, brown-rot, and curculio. The self-boiled lime-sulphur mixture (8–8–50) plus 2 pounds of arsenate of lead was used.

This combined treatment gave the following results: At picking time 95.5 per cent of the fruit on the sprayed block was free from brown-rot, 93.5 per cent free from scab, and 72.5 per cent free from curculio. On the unsprayed block only 37 per cent of the fruit was free from brown-rot, 1 per cent free from scab, and 2.5 per cent free from curculio injury. In packing the fruit for market it was found that the yield of merchantable fruit on the sprayed block was ten times as great as from the unsprayed block containing the same number of trees.

During the season of 1910 neither the brown-rot nor the plum curculio was so abundant in Georgia as the year previous, and the contrast between the sprayed and unsprayed blocks was, therefore, not so striking. Nevertheless, the very satisfactory results obtained fully substantiated the conclusions previously reached as to the value of spraying.

The work in Georgia was carried out at Fort Valley, Barnesville, and at Baldwin. At Fort Valley a block of 1,064 nine-year-old Elberta trees was treated in the orchard of the United Orchard Company. In addition to numerous experiments planned to show the effect of treatments at different times and with different mixtures, the demonstration treatment was put in effect on a block of 848 Elberta trees, a similar number being left unsprayed for purposes of comparison. The trees were sprayed (1) as the calyxes were shedding, April 1, with 2 pounds of arsenate of lead and 3 pounds of lime in each 50 gallons of water; (2) two to three weeks later, April 19 and 20, with 8–8–50 self-boiled lime-sulphur and 2 pounds of arsenate of lead; (3) on June 17, about a month before the fruit ripened, with self-boiled lime-sulphur alone.

In order to determine the effect of the treatments, the fruit at picking time (July 12 to 15) was gathered from 68 trees in the sprayed block and from 63 trees in the unsprayed block. This fruit was

carefully graded into "merchantable" and "culls," with the results shown in Table III.

TABLE III.—*Results of demonstration spraying in the peach orchard of the United Orchard Company, Fort Valley, Ga., 1910.*

Plat.	Yield.	Merchantable fruit.	Culls.	Fruit affected with brown-rot.
	Bushels.	*Per cent.*	*Per cent.*	*Per cent.*
68 trees (sprayed)	101	86.2	13.7	5.3
63 trees (not sprayed)	92	54.6	46.4	20.0

It will be noted that from the 68 sprayed trees there was a total yield of 101 bushels, of which 86.2 per cent was merchantable and 13.7 per cent was culls. On the unsprayed block of 63 trees there was a total yield of 92 bushels of fruit, of which 54.6 per cent was merchantable and 46.4 per cent was culls, a gain in merchantable fruit due to the treatments of 31.6 per cent.

In the orchard of Mr. S. H. Bassett, also at Fort Valley, Ga., a block of 700 seven-year-old Elberta trees was sprayed as a demonstration and a like number of trees left unsprayed for comparison. The trees were sprayed as the calyxes were shedding, April 5, with 2 pounds of arsenate of lead to each 50 gallons of water and again on April 22 with self-boiled lime-sulphur (8–8–50) and 2 pounds of arsenate of lead. Owing to the difficulty of getting water, this block received no further treatment. On July 7, when the first picking of the crop was being made, the sprayed and unsprayed blocks were carefully examined for the purpose of making an estimate of the results of the treatment. The fruit on the sprayed block was highly colored and practically free from scab, brown-rot, and curculio. No specimens of fruit affected with these troubles could be found in a search of two hours throughout the block. The crop was decidedly heavier on the sprayed trees than on the unsprayed, the fruit from the latter having dropped from the effect of these combined troubles. In looking over the unsprayed block, it was estimated that 50 to 60 per cent of the crop had been destroyed or rendered unmerchantable by curculio, brown-rot, and scab.

In the operations at Barnesville, Ga., the same plan of spraying was carried out on a commercial scale in two different orchards. The improved condition of the fruit on the sprayed blocks in both of these orchards was a matter of much comment by the fruit growers in that section.

Owing to the almost complete absence of the curculio and the small amount of brown-rot in these orchards, the results were not as well marked as those obtained elsewhere. The peach scab, however, was quite abundant on the unsprayed fruit and practically absent on the sprayed blocks.

In the orchard of Mr. S. M. Marshburn, the demonstration treatment was given to 926 Elberta trees, 212 trees being left untreated for comparison.

From the sprayed trees the yield was 209 crates of extra fancy fruit, 587 crates of fancy fruit, with 51¾ bushels, or 96 crates, of culls, the total merchantable fruit being 92.02 per cent.

On the unsprayed trees the yield was 15¾ crates of extra fancy fruit, 135¼ crates of fancy fruit, with 21½ bushels, or 28⅔ crates, of culls, the percentage merchantable being 84.02.

In the A. O. Murphy orchard, the yield from 485 sprayed Elberta trees was 211 crates of extra fancy fruit, 272 crates of fancy fruit, with 68½ bushels, or 91⅓ crates, of culls, the total percentage merchantable being 84.09.

On the 110 unsprayed Elbertas in this orchard the yield was 8½ crates of extra fancy fruit, 109 crates of fancy fruit, and 45¼ bushels, or 60⅓ crates, of culls, the percentage merchantable being 66.07.

In the orchard of Mr. A. M. Kitchen, at Baldwin, Ga., experiments and demonstrations were conducted on the Carman, Hiley, Elberta, and Summerour, or Atlanta, varieties, 2,000 trees in all being treated and a similar block left untreated. The trees were 7 years old and bore a fair crop of fruit, although the crop was rather light in portions of the orchard. The Elberta and Summerour varieties were sprayed (1) as the calyxes were shedding, April 7 and 8, with arsenate of lead, 2 pounds to 50 gallons of water; (2) on April 27 and 28, with 8–8–50 self-boiled lime-sulphur and 2 pounds of arsenate of lead; and (3) on June 17 and 18, about a month before the fruit ripened, with 8–8–50 self-boiled lime-sulphur. The Carman and Hiley varieties received the same treatment, with the omission of the third application. At picking time the fruit from 5 to 11 sprayed trees and a like number of unsprayed trees in each variety was sorted and the results are shown in Table IV.

TABLE IV.—*Results from spraying the Carman, Hiley, Elberta, and Summerour varieties of peaches at Baldwin, Ga., 1910.*

Varieties and dates of spraying.	Total fruits.	Fruit affected with brown-rot.	Fruit affected with scab.	Fruit badly affected with scab.	Merchantable fruit.	Culls.
Sprayed:	*Number.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Carman, Apr. 7 and 27	1,884	0.1	15.9	0.00	97.6	2.4
Hiley, Apr. 7 and 27	1,446	.2	28.0	.00	96.3	3.7
Elberta, Apr. 7, 27, and June 17	3,443	.7	41.4	.03	97.7	2.3
Summerour, Apr. 7, 27, and June 17.	4,360	9.3	[1] 7.7	.80	82.6	17.4
Unsprayed:						
Carman	1,417	31.8	92.9	16.40	40.2	59.8
Hiley	739	28.1	99.4	19.00	51.5	48.5
Elberta	1,291	70.0	100.0	16.00	16.9	83.1
Summerour	5,308	54.8	[1] 91.7	72.50	7.5	92.5

[1] In sorting this variety, fruits that showed only a few inconspicuous spots were not counted as scabby, while all the affected fruit of the other varieties was counted.

It will be seen from Table IV that the brown-rot was thoroughly controlled, even where 70 per cent of the unsprayed fruit rotted, as was the case with the Elberta. The scab was also held down so that it was commercially negligible. The Summerour is particularly susceptible to scab, and has been unprofitable in Mr. Kitchen's orchard on account of this disease. On the unsprayed trees 72.5 per cent of the fruit was badly affected with scab, while less than 1 per cent of the sprayed fruit was badly affected. By referring to the column showing the percentage of merchantable fruit in Table IV it will be seen that from 82.6 to 97.7 per cent of the sprayed fruit was merchantable and from 7.5 to 51.5 per cent of the unsprayed fruit was merchantable. The difference between these two sets of figures represents the difference between success and failure.

In Table V are shown the results from 12 sprayed and 12 unsprayed Elberta trees in the same orchard and given the same treatment as those considered in Table IV, but located in a different section of the orchard. The fruit was picked from July 26 to August 1 and sorted with reference to brown-rot, scab, and curculio. To determine the presence or absence of the curculio all the fruit was sliced into several pieces.

TABLE V.—*Results from 12 sprayed and 12 unsprayed Elberta peach trees at Baldwin, Ga., 1910.*

Plats.	Total fruits.	Fruit affected with scab.	Fruit badly affected with scab.	Fruit affected with brown-rot.	Fruit affected with curculio.	Merchantable fruit.	Culls.
	No.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Sprayed	5,197	39.26	0.03	0.90	13.15	97.61	2.39
Unsprayed	3,907	100.00	9.29	18.04	51.19	46.49	53.51

It will be seen from Table V that 0.9 per cent of the sprayed fruit was affected with brown-rot, 39.26 per cent with scab (practically none of which was bad), and 13.15 per cent with curculio, while 18.04 per cent of the unsprayed fruit was affected with brown-rot, 100 per cent with scab, and 51.19 per cent with curculio. It is also shown that 97.61 per cent of the sprayed fruit was merchantable, as against 46.49 per cent of the unsprayed fruit. Had all the fruit infested with curculio been thrown out the percentage of merchantable fruit from both the sprayed and the unsprayed trees would not have been quite so high. Much of the infestation consisted of young worms just hatched, and in such cases the market value of the fruit had not been materially affected. In addition to these 12 trees the crop from a block of 70 sprayed and 70 unsprayed Elberta trees was sorted and packed for the market. It was found that 97.04 per cent of the fruit of the sprayed block was merchantable, leaving 2.96 per cent as culls. From the unsprayed block only 54.11 per cent of the crop was merchantable and 45.89 per cent unmerchantable, a gain of 42.93 per cent.

A block of 1,000 Summerour trees, which is a late-maturing variety, ripening at Baldwin last season, August 27 to 31, was given

the same treatment received by the Elbertas. In order to determine the commercial results the crop from 70 sprayed trees and the same number of unsprayed trees was graded at the packing house. It was found that 85 per cent of the sprayed fruit was merchantable, leaving 14.98 per cent unmerchantable. Only 6.49 per cent of the unsprayed fruit from 70 trees was merchantable, 93.51 per cent being totally unfit for market. This shows a gain from spraying of 78.53 per cent. This great loss was due to the combined effect of the curculio, brown-rot, and scab, although the latter was the most prominent trouble. These commercial results show conclusively that even under severe conditions the combination treatment will effectually control these troubles.

It will be understood that the combination treatment for these diseases and curculio is in effect a compromise. Considered only from the insect standpoint, an additional application of arsenate of lead would be desirable, but a third application of the poison is as a rule unsafe. Nevertheless, the benefits from two applications of arsenate of lead has been very marked. In order to show more in detail the effect of two such treatments on the curculio, Table VI is presented, showing the results of an examination for curculio infestation of the dropped fruits during the season, as well as those on the trees at picking time, 12 trees in the sprayed block and 12 trees in the unsprayed block being examined.

TABLE VI.—*Results of spraying Elberta peaches for plum curculio, Baldwin, Ga., 1910.*

Plat No.	Treatment.	Tree No.	Fruit from ground.		Fruit from tree.		Total number of fruits.	Total number of fruit infested.	Sound fruit.[1]
			Total number.	Number infested.	Total number.	Number infested.			
									Per cent.
1	First application, Apr. 7–8, arsenate of lead, 2 pounds to 50 gallons of water; second application, 2 pounds of arsenate of lead in self-boiled lime-sulphur wash (8–8–50), Apr. 27–28; third application, lime-sulphur wash only (8–8–50), June 17–18.	1	447	7	589	26	1,036	33	96.81
		2	119	8	465	45	584	53	90.92
		3	177	10	388	65	565	75	86.72
		4	363	24	606	76	969	100	88.63
		5	161	10	335	61	496	71	85.68
		6	96	12	409	26	505	38	92.47
		7	99	2	358	38	457	40	91.23
		8	222	22	293	33	515	55	89.32
		9	702	25	412	123	1,114	148	86.71
		10	224	6	476	83	700	89	87.28
		11	68	7	410	50	478	57	88.07
		12	348	17	456	58	804	75	90.67
		Total.	3,026	150	5,197	684	8,223	834	.....
2	Untreated.....	1	188	115	324	178	512	293	42.77
		2	187	83	385	132	572	215	62.41
		3	147	85	280	155	427	240	43.79
		4	839	114	648	239	1,487	353	76.26
		5	76	56	129	79	205	135	34.14
		6	605	165	471	189	1,076	354	67.10
		7	192	71	177	94	369	165	55.28
		8	318	55	299	147	617	202	67.26
		9	68	67	388	251	456	318	30.26
		10	143	67	176	137	319	204	36.05
		11	214	110	347	231	561	341	39.21
		12	274	100	283	168	557	268	51.88
		Total.	3,251	1,088	3,907	2,000	7,158	3,088	.....

[1] The average of sound fruit on treated trees was 89.85 per cent; on untreated trees, 56.85 per cent.

In the sprayed block 8,223 fruits were obtained, of which 834, or 10.15 per cent, were infested. From the unsprayed block there was a total of 7,158 fruits, of which 3,088 were infested, the percentage of sound fruit being 56.85, a gain in yield of 33 per cent of fruit free from curculio infestation.

EXPERIMENTS IN WEST VIRGINIA, 1910.

In order to demonstrate the control of peach scab and to determine how much spraying is required on late varieties, an experiment was conducted in the orchard of L. P. Miller & Bros., at Okonoko, W. Va., during 1910. There are about 600 acres of 12-year-old trees in this orchard, and it is composed of a large number of varieties, beginning with Southern Early and ending with Bilyeu. Until summer spraying was undertaken in 1908 the peach scab had been most disastrous to the crops in this orchard, about one-half of the fruit being lost every year. Spraying, however, largely overcame the trouble, and in 1910 the loss was comparatively small, notwithstanding the difficulty of thoroughly spraying such a large orchard at the proper time.

The spraying experiments were confined to the Elberta, Salway, and Bilyeu, and about 500 trees each of these varieties were used. The Bilyeu set a good crop, while the crop of Elberta and Salway was only medium to light, but ample for an experiment. For the most part the weather was unfavorable for good work. During the time the first and second applications were being made it was cloudy and showery and the day following the second application it rained rather hard all day. The Elberta trees were sprayed according to the following plan:

Plat 1.—Self-boiled lime-sulphur and arsenate of lead, one month after petals fell, May 11.

Plat 2.—Self-boiled lime-sulphur with arsenate of lead, one month after petals fell, and self-boiled lime-sulphur alone, one month later, May 11 and June 15.

Plat 3.—Self-boiled lime-sulphur, one month after petals fell and one month later, May 11 and June 15.

Plat 5.—Self-boiled lime-sulphur six weeks after petals fell and one month later, May 26 and June 28.

Plat 6.—Commercial lime-sulphur, 1 to 100 with arsenate of lead and lime, one month after petals fell, and with lime only one month later.

Plat 0.—Check; untreated.

At picking time, August 22 to 26, the crop, including windfalls, from four trees in each sprayed plat and six unsprayed trees was sorted to determine the percentage of fruit affected with scab and the percentage of merchantable fruit. The results are shown in Table VII.

TABLE VII.—*Results of treatment for peach scab on the Elberta variety, Okonoko, W. Va., 1910.*

Plats.	Total fruits.	Fruit affected with scab.	Fruit badly affected with scab.	Merchantable fruit.	Culls.
	Number.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	1,322	65.2	3.0	86.1	13.9
2	1,566	20.9	0.1	95.5	4.5
3	2,277	20.2	1.4	93.1	6.9
5	1,819	55.8	0.9	93.6	6.4
6	1,924	49.3	1.5	93.9	6.1
Check	2,918	99.6	41.1	53.7	46.3

The third column of the above table shows the percentage of fruit affected with scab, including fruit so slightly affected that its market value was not materially reduced, while the fourth column shows the percentage of badly affected, unmerchantable fruit. The fifth column shows the percentage of good, merchantable fruit obtained from each plat, while the sixth column shows the percentage of culls due to scab, brown-rot, curculio, and other causes.

Plat 1 received only one application, and the results were all that could be expected in a wet season, such as last spring. Although 65.2 per cent of the fruit was affected with scab, only 3 per cent of it was badly affected.

Plats 2 and 3, which were sprayed twice, gave the best results, only a little more than 20 per cent of the fruit in each being affected with scab. Most of this scab infection was commercially negligible, the spots being small and rather inconspicuous. In plat 2 less than 1 per cent of the fruit was badly affected, and in plat 3 only 1.4 per cent was so affected. The only difference in the treatment received by these two plats was the use of arsenate of lead with the self-boiled lime-sulphur in the first application on plat 2. This made no difference in the control of scab. It apparently raised the percentage of merchantable fruit, plat 2 having 95.5 per cent and plat 3 having 93.1 per cent. This difference would certainly have been greater had there been more curculio in the orchard.

The good results obtained from the treatment of these two plats may be better appreciated by comparing them with the results from the unsprayed trees. Practically all (99.6 per cent) of the unsprayed fruit was affected with scab and 41.1 per cent of it was badly affected. Only 53.7 per cent of the fruit was suitable for market, leaving 46.3 per cent of culls.

Plat 5 received the same treatment as plat 3, except that both applications were delayed two weeks. The results indicate that one month after the petals fall is a better time to begin spraying for scab than two weeks later.

Plat 6, which was sprayed with commercial lime-sulphur solution, 1 gallon to 100 gallons of water, had only 1.5 per cent of fruit badly affected with scab, although 49.3 per cent of it was affected more or less. These results indicate that the scab can be held in check by a very dilute solution of the lime-sulphur solution. It burned the foliage considerably and caused some of the leaves to drop, but the injury almost disappeared as the season advanced and the fruit matured in good condition.

A similar test was made on the Salway variety, which ripens some four weeks later than the Elberta. There were four sprayed plats, consisting of about 80 trees each, and 17 trees were left untreated for the purpose of comparison. The self-boiled lime-sulphur (8–8–50) was used in each application, and arsenate of lead at the rate of 2 pounds to each 50 gallons was added in the first application only.

On September 22 and 23 the crop from four trees in each plat was sorted for scab and brown-rot, and the results are shown in Table VIII. In this case the classification of scabby fruit was made on a commercial basis; that is, the fruit having only a few small specks of scab, which did not materially detract from its market value, was not classed as scabby. The figures given in the table therefore represent the percentage of fruit so badly affected as to have but little value on the market.

TABLE VIII.—*Results of spraying on the Salway variety in the Miller orchard, Okonoko, W. Va., 1910.*

Plat No.	Dates of spraying.	Total fruits.	Scabby fruit.	Rotted fruit.
		Number.	*Per cent.*	*Per cent.*
8	(1) One month after petals fell, May 12; (2) June 17; (3) July 15	1,557	5.5	2.5
9	(1) One month after petals fell, May 12; (2) June 17	1,599	5.3	1.9
10	(1) One month after petals fell, May 12	1,132	27.2	6.8
11	(1) Six weeks after petals fell, May 26; (2) June 28	1,065	5.8	1.3
12	Check; not sprayed	2,349	87.5	37.6

It will be observed that the results from plat 8, which had three applications, are about the same as those from plat 9, which had two applications, the scab and brown-rot having been almost completely controlled in both cases. The results of the treatment of plat 9 are shown in figures 9 and 11. The superiority of two treatments over one may be seen by comparing plats 9 and 10. The latter received only one application and 27.2 per cent of the fruit became affected with scab, while only 5.3 per cent of the crop on plat 9 was affected. Plat 11 received the same treatment as plat 9, except that the applications on plat 11 were delayed two weeks, the object being to determine the best time to begin the spraying. In this case there was very little difference in the results from the two plats.

Of the fruit from the unsprayed trees, 87.5 per cent was rather badly affected with scab and 37.6 per cent was affected with brown-rot, as shown in figures 10 and 12. In other words, the unsprayed crop was almost a total loss.

The Bilyeu variety was given the same treatment as that applied to Salway and the results were about the same. In this case the fruit was not sorted and counted, but at picking time comparative notes were made, attempting to show the estimated percentages of brown-rot and scab. Fully 50 per cent of the unsprayed fruit was lost on account of these diseases, while there was a loss of only about 5 per cent of the fruit sprayed twice, although much of it showed some

FIG. 9.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Scabby fruit in single basket on the left; remainder of the crop sound.

slight spotting with scab. On the plat sprayed three times the scab was almost entirely prevented. In most cases three treatments will be necessary for the best results against scab on late-maturing varieties like the Bilyeu.

EXPERIENCE OF FRUIT GROWERS.

Following the recommendations of the United States Department of Agriculture, a considerable number of fruit growers have adopted the combination treatment, and in Georgia during 1910 perhaps not less than one-fourth of the peach orchards were sprayed for the curculio, brown-rot, and scab. In connection with the department's experiments at Fort Valley, Barnesville, and Baldwin, Ga., an effort was made to give personal instruction to as many orchardists as pos-

sible in order to start them in the work, and by visits and by correspondence assistance was rendered to growers in other parts of the State. Thus at Fort Valley the Hale Georgia Orchard Co. sprayed three times its entire bearing orchard of about 100,000 trees. The same schedule of treatments was also adopted by Mr. W. C. Wright in his orchard of 60,000 trees and by others in the immediate neighborhood. Also at Marshallville, Ga., the treatment was adopted by Mr. S. H. Rumph and other leading growers, the total number of trees sprayed in this general section aggregating about a million.

At Barnesville, Ga., practically all of the large orchardists used the combined spray, aggregating not less than 500,000 trees. At Baldwin, Ga., some of the leading growers sprayed not less than 100,000

FIG. 10.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Sound fruit in three baskets on the left; remainder of the crop scabby.

trees. Messrs. Stranahan Bros., of Warm Springs, Ga., have been spraying for the past three years and were among the first large peach orchardists to adopt the lime-sulphur treatment even before it was out of its experimental stage. Also around Adairsville and at numerous other points in Georgia spraying was adopted by the leading growers, at least 2,000,000 trees for the State as a whole being sprayed. Considering all of the Southeastern States it is probable that in this territory 3,000,000 trees were sprayed during 1910.

Considerable spraying has also been done by peach orchardists in West Virginia, western Maryland, and Pennsylvania, including a total of perhaps 1,000,000 trees. The treatment has also been adopted by some growers in Illinois, Missouri, and Arkansas, aggregating about

500,000 trees, making on a conservative estimate a grand total of 4,500,000 to 5,000,000 trees sprayed during 1910 with the self-boiled lime-sulphur wash and arsenate of lead.

We have been able to personally examine some of these orchards, and have had reports from many of the orchardists regarding the results of the treatment. So far as it has been possible to determine, the results have been uniformly satisfactory and the slight injury from the spray comparatively unimportant. It seems rather remarkable that so many growers in different parts of the country should be so successful in using a new treatment for the first time. This may be taken to indicate the entire practicability of the recommendations.

EFFECT OF SPRAYING ON THE QUALITY OF THE FRUIT.

The good results from the treatment do not end with the control of the curculio, scab, and brown-rot. The sprayed fruit is as a rule

FIG. 11.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Rotten fruit in upturned basket on the left; remainder free from rot.

somewhat larger, much more highly colored, and firmer than unsprayed fruit. It keeps longer, carries to the market in better condition, and brings better prices. A carload of Elberta peaches shipped from Baldwin, Ga., on July 29 contained 166 crates of sprayed fruit and 324 crates of unsprayed fruit. This fruit was sold on the New York market on August 2, the 166 crates of sprayed fruit bringing $2.50 per crate, while the 324 crates of unsprayed fruit brought an average of $1.75 per crate, a difference of 75 cents per crate in favor of the sprayed fruit.

The effect of the treatments is to fairly clean the fruit from disease and to put it in a more or less sterilized condition, adding greatly to its keeping quality. This superiority of sprayed as against unsprayed fruit is one of the marked benefits and has been noted by all growers who have adopted the treatment.

On July 14 sprayed and unsprayed Elberta fruit in the Hale orchard at Fort Valley, Ga., was picked and packed for a shipping test, but owing to a car shortage was not shipped. There were 64 crates of unsprayed fruit and 400 crates of sprayed fruit. This fruit was stacked out on the ground where it remained in the sun and during occasional showers of rain until July 18 (4 days) and then 6 crates of each lot

FIG. 12.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Fruit in six baskets on the right affected with brown-rot; the remainder free from rot, but scabby.

were examined for brown-rot. It was found that 62.7 per cent of the unsprayed fruit had rotted, while only 8 per cent of the sprayed fruit was so affected, showing conclusively the better keeping quality of the latter.

EFFECT OF THE SELF-BOILED LIME-SULPHUR WASH ON SCALE INSECTS.

Observations and experiments go to show that, when used as a summer spray, the effect of the self-boiled lime-sulphur wash on the control of scale insects which may be present on the trees, especially the San Jose scale, is important. While to secure the best results in the control of scale insects it would be desirable to coat the limbs and twigs more thoroughly than is accomplished in ordinary summer spraying,

nevertheless in the course of the work as practiced against the curculio, brown-rot, and scab noticeable good is accomplished. Although the spray is not strong enough to kill many of the adult scale insects, it is effective to an important extent in bringing about the death of the young scales. Experiments made by the Bureau of Entomology in the use of the self-boiled lime-sulphur wash as a summer spray for the San Jose scale[1] have shown that two or three applications will result in a marked improvement in the condition of the trees by fall. The effect of the wash is to prevent the settling of the young scales upon the twigs and branches, so that by the close of the season the trees are largely free from the insects.

Further observations are necessary to determine just how much benefit will result from these applications in the control of scale insects, but it seems probable in peach orchards regularly sprayed for the curculio and for scab and brown-rot that the usual winter treatments for the San Jose scale may be reduced to perhaps one application every two or three years. Any observant orchardist should be able to determine for himself the necessity for winter treatments, depending upon the abundance of the scale insects. The lime-sulphur wash is furthermore effective against numerous other sucking insects, especially plant lice, which may be present on the trees.

PREPARATION AND USE OF THE SPRAY.

Spraying for the brown-rot, scab, and curculio does not differ in principle from the usual spraying practices. It is essential that an efficient spraying outfit be employed, so that the work may be done expeditiously and with thoroughness. Where the orchard interest is at all important it will be desirable to employ a power sprayer, such as a gasoline or compressed-air outfit. Excellent work, however, may be done with the ordinary barrel sprayer, which is suitable for orchards of a few hundred trees. In applying the spray, all parts of the tree should be reached. This is especially important in the first application, which is directed principally against the plum curculio. The purpose should be to coat thoroughly the foliage, twigs, and young fruit to insure to the fullest extent possible the poisoning of the beetles. The same precautions as to poisoning the foliage, fruit, and buds are also essential in making the second application, as the beetles are still very numerous, feeding and ovipositing freely. (See Table II.) This is also the most important application for the prevention of scab infection, which is prevented only by thoroughly coating the young fruits. In subsequent applications the efforts should be directed more to coating the fruit with the spray to protect it from brown-rot infection, especially as it begins to ripen.

[1] Reported in the Journal of Economic Entomology, vol. 2, p. 130

The schedule of applications (pp. 38–40) takes account of the ripening period of the principal commercial varieties of peaches. Applications made later than a month or six weeks before picking time are likely to result in the fruit being more or less spotted with the spray when harvested, somewhat marring its appearance for market purposes. This danger can be largely avoided by using nozzles which throw a mistlike spray, coating the fruit with very fine dots rather than with large blotches.

DIRECTIONS FOR THE PREPARATION OF SELF-BOILED LIME-SULPHUR WASH.

The standard self-boiled lime-sulphur mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur to 50 gallons of water. In mild cases of brown-rot and scab a weaker mixture containing 6 pounds of each ingredient to 50 gallons of water may be used with satisfactory results. The materials cost so little, however, that one should not economize in this direction where a valuable fruit crop is at stake. Any finely powdered sulphur (flowers, flour, or "commercial ground" sulphur) may be used in the preparation of the mixture.

In order to secure the best action from the lime, the mixture should be prepared in rather large quantities, at least enough for 200 gallons of spray, using 32 pounds of lime and 32 pounds of sulphur. The lime should be placed in a barrel and enough water (about 6 gallons) poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps, if any are present. The mixture should be constantly stirred and more water (3 or 4 gallons) added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot for 15 or 20 minutes after the slaking is completed, the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat,

violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through the strainer.

DIRECTIONS FOR USING ARSENATE OF LEAD.

Many experiments have shown that well-made arsenate of lead is much the safest of all available arsenicals for use on the peach. Arsenate of lead is to be found on the market both as a powder and as a putty-like paste, which latter must be worked free in water before it is added to the lime-sulphur mixture. The paste form of the poison is largely used at the rate of about 2 pounds to each 50 gallons of the lime-sulphur wash and is added, after it has been well worked free in water, to the lime-sulphur spray previously prepared. As there are numerous brands of arsenate of lead upon the market, the grower should be careful to purchase from reliable firms. A decided change in color will result when the arsenate of lead is added to the lime-sulphur mixture, due to certain chemical changes which, in the experience of the writers, do not injuriously affect the fungicidal and insecticidal properties of the spray or result in injury to the foliage.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead, as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred, each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed, and thinned with water. In all cases the arsenate of lead solution should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

DANGER OF INJURY FROM SPRAYING.

As stated elsewhere in this bulletin, the foliage of the peach is extremely sensitive to injury from such sprays as Bordeaux mixture and arsenicals, such as Paris green, arsenate of lead, etc. This sensitiveness has been the sole reason why it has been impracticable to spray peach orchards with fungicides and insecticides such as Bordeaux mixture or Paris green, as has for years been the custom in the case of apples, grapes, and other deciduous fruits.

Of the various arsenicals available for use, well-made arsenate of lead has proved to be the safest. Shortly after the development of this comparatively new insecticide, it was at once extensively experimented with on peaches by numerous entomologists and it was tried to a limited extent by peach growers. A single application of arsenate of lead in water did not result in injury so important as to prevent its use. However, when two or three applications were made, as is necessary in the control of the curculio, serious shot-holing and falling of the leaves and even burning of the fruit resulted, the latter, in extreme cases, falling to the ground. The use of lime with arsenate of lead lessened the danger of injury considerably, but used even in this way for two or three treatments, especially under certain weather conditions, resulted in extensive injury to foliage and fruit.

When it was established that the self-boiled lime-sulphur wash was an effective fungicide and entirely safe as a spray for the peach, one of the interesting questions presented was whether arsenate of lead might be safely used with it to effect a combination spray for both insects and diseases. While on chemical grounds it appeared that the addition of arsenate of lead to the self-boiled lime-sulphur mixture would result in an important decomposition of the spray and greatly add to its probable injurious character, in practice the combined spray was found to be entirely safe. Observations extending over three seasons have failed to show any serious injury resulting from the use of this spray, even when as many as three applications were made. Thus, in the test of numerous brands of arsenate of lead at Barnesville, Ga., during 1910, carried out by Mr. E. W. Scott, of the Bureau of Entomology, peach trees were given three thorough applications: (1) With arsenate of lead in limewater at the rate of 2 pounds to 50 gallons, and (2) in the self-boiled lime-sulphur wash used at the same strength. In all cases very serious injury resulted to fruit and foliage on the plats sprayed with the arsenate of lead in limewater, whereas there was no discernible injury on the plats treated with arsenate of lead in the self-boiled lime-sulphur wash. It is not understood why the arsenate of lead apparently loses its injurious properties when used in the self-boiled lime-sulphur wash, though its safe employment in this way is most fortunate.

In the schedule of applications only two arsenate of lead treatments are recommended, as these will measurably control the curculio and a third treatment would considerably increase the danger of injury. Where the curculio is very destructive, however, the grower should use his judgment as to whether a third application of the poison would be advantageous.

The effect of the arsenate of lead upon the fruit is to increase its color notably. This increase in color from two applications in

self-boiled lime-sulphur wash improves the appearance of the fruit. Three or even two applications of the poison alone or in limewater, however, result in a very excessive reddening, especially on the side exposed to the sun, on which later may appear brown, sunken spots of variable size, accompanied with more or less extensive cracking of the skin. This condition of the fruit is shown in figure 13.

The self-boiled lime-sulphur mixture when properly prepared according to directions does not injure the fruit or foliage, but if allowed to remain hot in concentrated form before dilution enough sulphur may go into solution to produce injury to the foliage. Users of this spray should therefore follow carefully the directions given for its preparation, bearing in mind that a good mechanical mixture of the sulphur and lime suspended in water and only slightly combined is desired rather than to dissolve any considerable quantity of the sulphur.

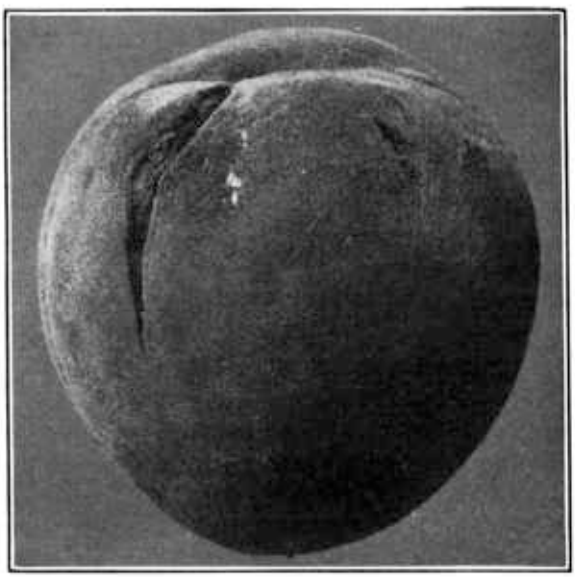

FIG. 13.—Elberta peach sprayed three times with arsenate of lead, showing the browning and cracking effect of the poison.

During the application of the spray, it is very important that the mixture be kept well agitated to insure its uniform distribution. As both the self-boiled lime-sulphur wash and the arsenate of lead quickly settle when the spray is left undisturbed, an excessive amount may be applied to some trees, while others receive an insufficient quantity. While most spraying equipments are supplied with adequate agitating apparatus, the orchardist should assure himself that the spray is being properly stirred in the tank during its application. Under conditions of imperfect agitation and consequent settling, the ingredients of the spray may be applied so strong that serious injury will result. This has been observed to be the case, especially following the employment of compressed-air sprayers with inefficient agitators.

COST OF TREATMENT.

The cost of the combined treatment for the control of brown-rot, scab, and curculio is insignificant when compared with the resulting

benefits. The trees at Baldwin, Ga., were sprayed with a good hand outfit, and 3 men were able to spray 1,000 trees a day. With labor at 75 cents a day (the wages paid in that section), arsenate of lead at 10 cents a pound, sulphur at 2½ cents a pound, and lime at $1.10 a barrel, the cost for three treatments was $27.60 a thousand, or a little less than 3 cents a tree. At Fort Valley, Ga., a gasoline-power sprayer was used. The trees there were larger and the water was not so convenient, making the cost somewhat higher than at Baldwin. In this case the cost of three treatments was $32 a thousand, or a little more than 3 cents a tree. Where wages are higher the cost will be somewhat greater. For three treatments, the first with arsenate of lead alone, the second with self-boiled lime-sulphur and arsenate of lead, and the third with self-boiled lime-sulphur alone, the cost will range from 3 to 5 cents per tree, depending upon the labor conditions, the size of the trees, the convenience of the water supply, and the equipment used. For average-sized 7-year-old trees, as a rule 1 gallon of spray per tree will be required for each application. In the first application not quite so much will be required, owing to scant foliage at that time, while a little more will be required for the second treatment. The third application should be lighter than the second, using finer nozzles so as to avoid staining the fruit with blotches of lime.

From the experience of the writers it seems safe to conclude that in most of the peach orchards of the eastern United States an increase per tree of at least one-half bushel of good merchantable fruit, worth about 50 cents, may be obtained from spraying at a cost of 3 to 5 cents. Spraying, therefore, is the most profitable of all the orchard operations.

SCHEDULE OF APPLICATIONS.

Most of the peach orchards in the eastern half of the United States should be given the combined treatment for brown-rot, scab, and curculio. This is particularly true of the southern orchards, where all these troubles are prevalent. In some of the more northern orchards the curculio is not very troublesome, but as a rule it will probably pay to add the arsenate of lead in at least the first lime-sulphur application.

The self-boiled lime-sulphur mixture referred to in the following outlines of treatment should be made of a strength of 8 pounds of lime and 8 pounds of sulphur to each 50 gallons of water, and the arsenate of lead should be used at the rate of 2 pounds to each 50 gallons of the mixture or of water. When the poison is used in water there should be added the milk of lime made from slaking 2 to 3 pounds of good stone lime. When used in the lime-sulphur mixture additional lime will not be necessary.

Midseason varieties.—The midseason varieties of peaches, such as Reeves, Belle, Early Crawford, Elberta, Late Crawford, Chairs, Fox, and Beers Smock, should be sprayed as follows:

(1) With arsenate of lead alone, about 10 days after the petals fall, or at the time the calyxes are shedding. (Fig. 14.)

FIG. 14.—Young peaches, showing the earliest and latest stages at which the first arsenate of lead treatment should be made.

(2) With self-boiled lime-sulphur and arsenate of lead, two weeks later, or four to five weeks after the petals have been shed.

(3) With self-boiled lime-sulphur alone, four to five weeks before the fruit ripens.

Late varieties.—The Salway, Heath, Bilyeu, and varieties with a similar ripening period should be given the same treatment prescribed

for midseason varieties, with an additional treatment of self-boiled lime-sulphur alone, to be applied three or four weeks after the second application.

Early varieties.—The Greensboro, Carman, Hiley, Mountain Rose, and varieties having the same ripening period should receive the first and second applications prescribed for midseason varieties.

Where the curculio is not particularly bad, as in Connecticut, western New York, and Michigan, the first treatment, which is for this insect only, may be omitted. Also for numerous orchards throughout the Middle States where the insect, especially in the younger orchards, is not yet very troublesome, orchardists should use their judgment as to whether the first application may be safely omitted. Where peach scab is the chief trouble, and brown-rot and curculio are of only minor importance, as may be the case in some of the Allegheny Mountain districts, satisfactory results may be had from two applications, namely, the first with self-boiled lime-sulphur and arsenate of lead four to five weeks after the petals fall, and the second treatment of the above schedule with self-boiled lime-sulphur alone three to four weeks later. These two treatments, if thoroughly applied, will control the scab and brown-rot, especially on the early and midseason varieties, and will materially reduce curculio injuries. Even one application of the combined spray made about five weeks after the petals fall would pay well, although this is recommended only for conditions where it is not feasible to do more.

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